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Optimising a total food refrigeration system

Introduction

- Outline the aim of this part of the project.
- Describe a new interactive refrigerator simulator and its uses.
- Describe a new interactive refrigeration system simulator based around a cold-store or freezer installation and its uses.

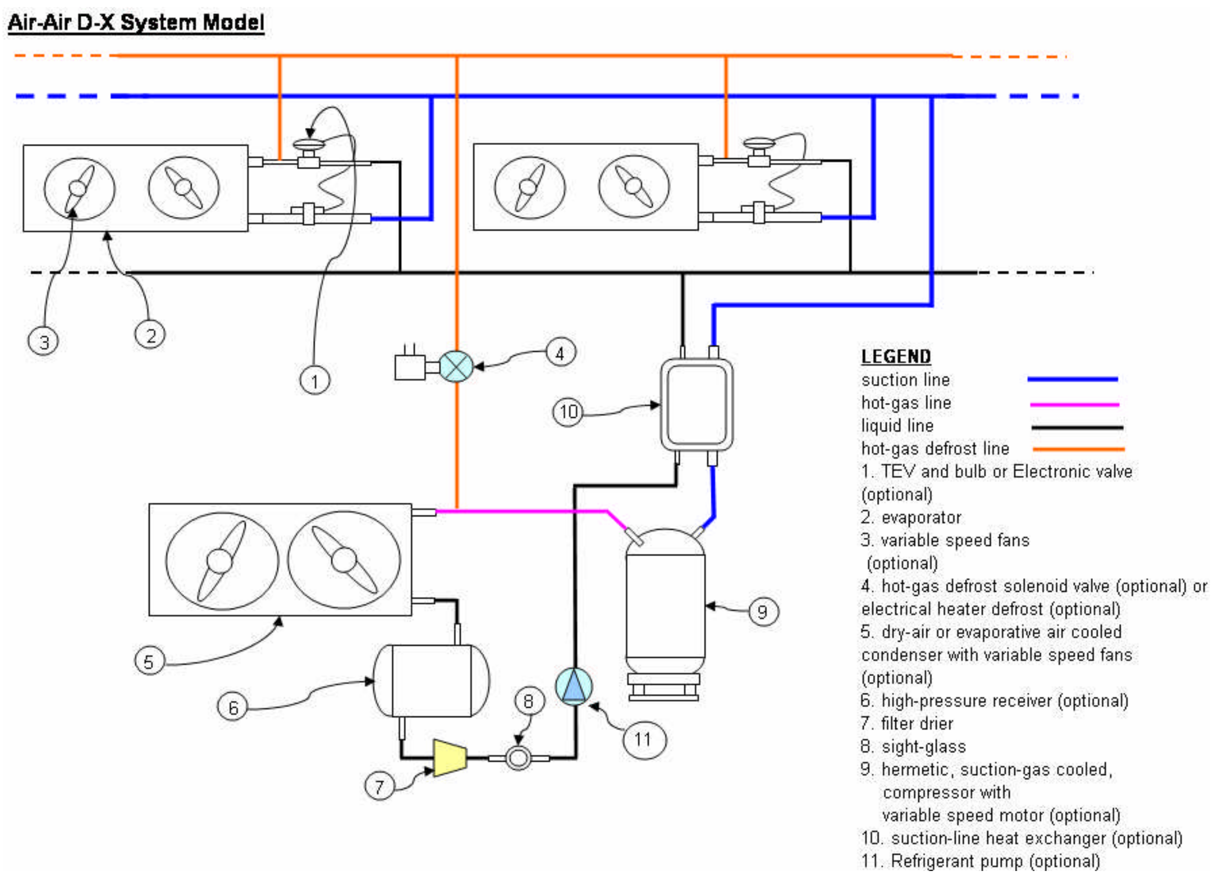
Project aims

The general objective of this part of the project is to develop scientifically based models of refrigeration systems common across the food chain, so as to allow study of performance and component choice.

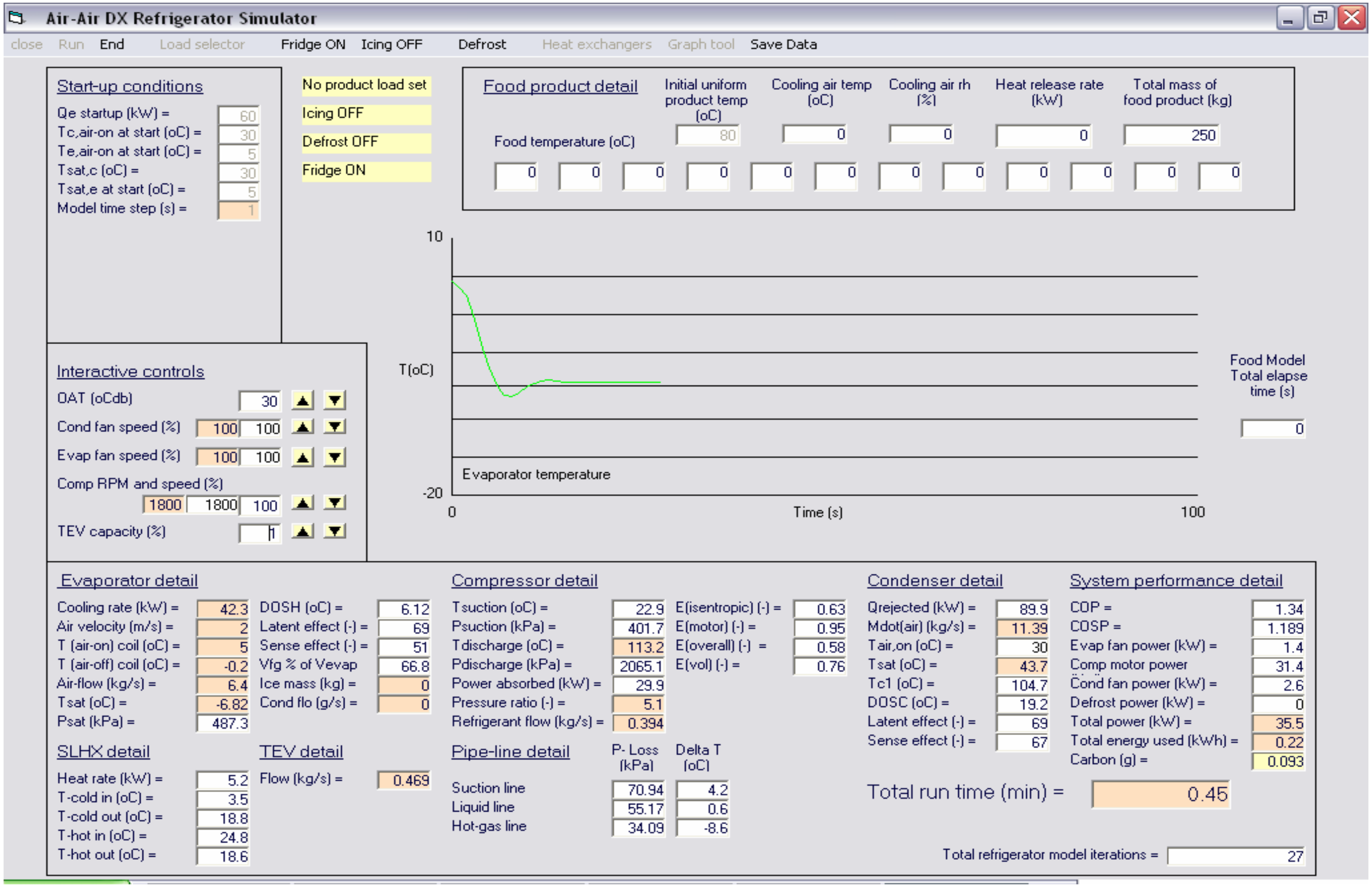
What type of system?

Our preliminary investigations suggested that Air-Air DX types of refrigerators are most commonly used by the food processing industry – therefore this is where we started modelling …

Our preliminary model



An interactive refrigerator development model



What the software provides:

Before pressing the RUN button you can …

- Input the required design cooling duty of the evaporator.
- Select the cooling efficiency of the condenser and/or evaporator.
- Select the start-up evaporator and condenser air-on conditions.
- Select the start-up conditions for compressor, condenser and evaporator fan speeds.
- Select TEV capacity.
- Select the time-step of the data collection – normally up to 100hrs of simulated running time – but more or less if required.
- Select the scale of the Time axis in the graphical display.

DEFAULT VALUES USED FOR ALL THE ABOVE IF NO SELECTION MADE

When the model is running …

It allows you to:

- Vary evaporator and condenser fan speeds.
- Vary compressor speed.
- Vary TEV capacity
- Vary Outdoor temperature

When the model is running:

On-screen System performance data are displayed continuously, including total power, kWh consumed and CO_2 emissions.

Graphical output is provided.

The model will continue running until you tell it to stop by pressing END!

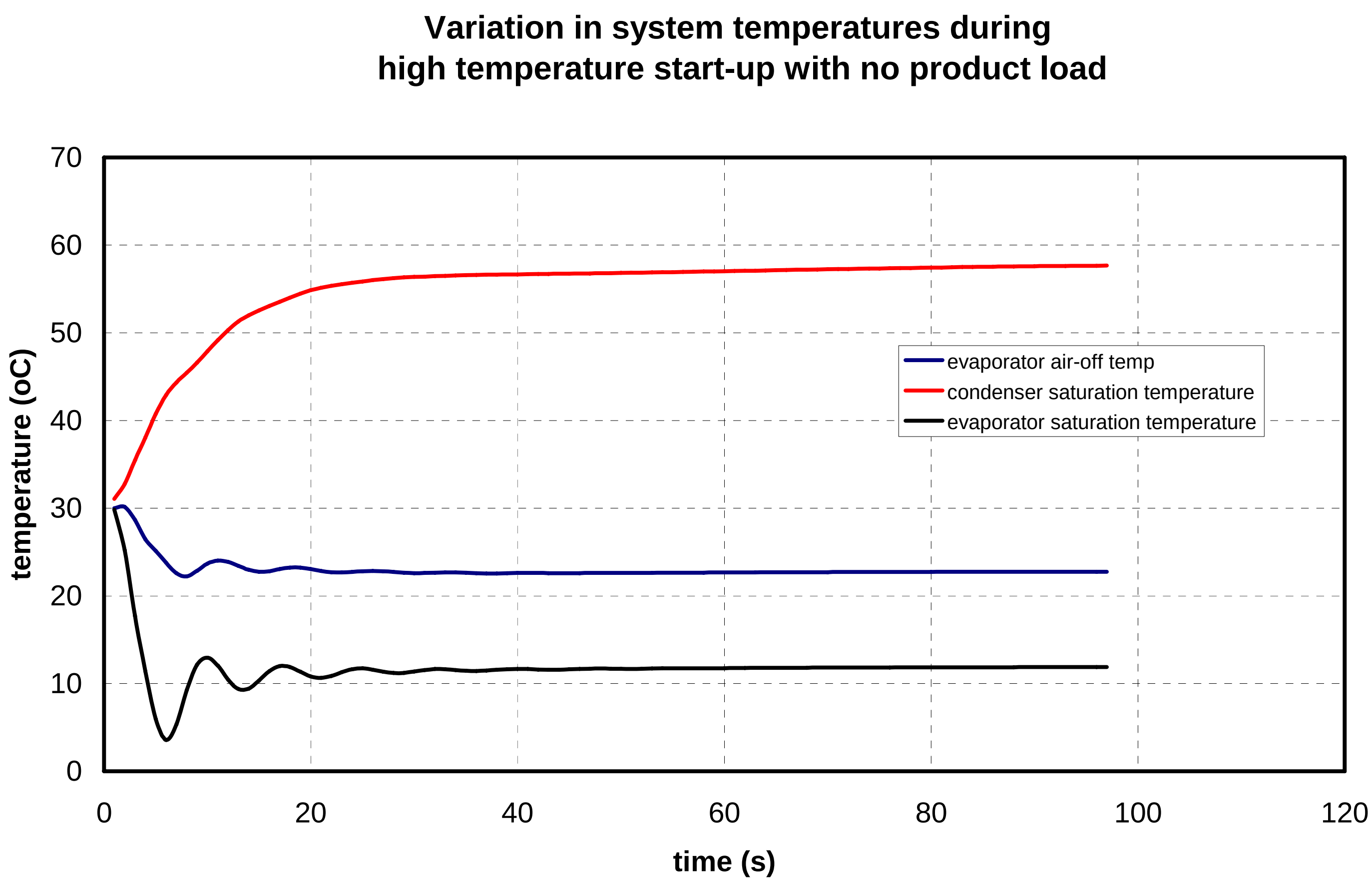
When the RUN-TIME is completed …

You can :

- SAVE your data to file for later spreadsheet analysis.
- Select different operating conditions and RUN the model again.

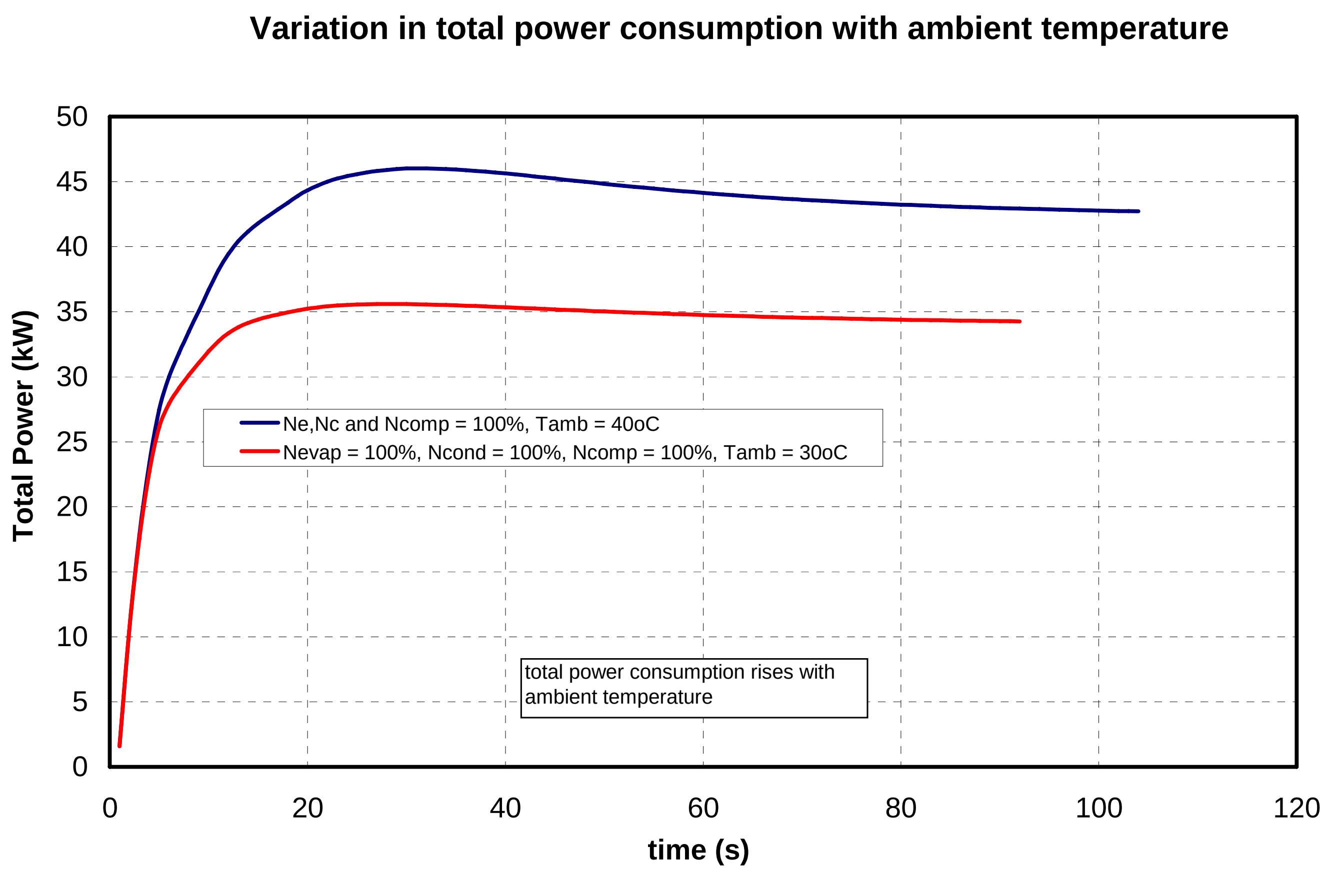
Some output data…

- **High temperature start-up**



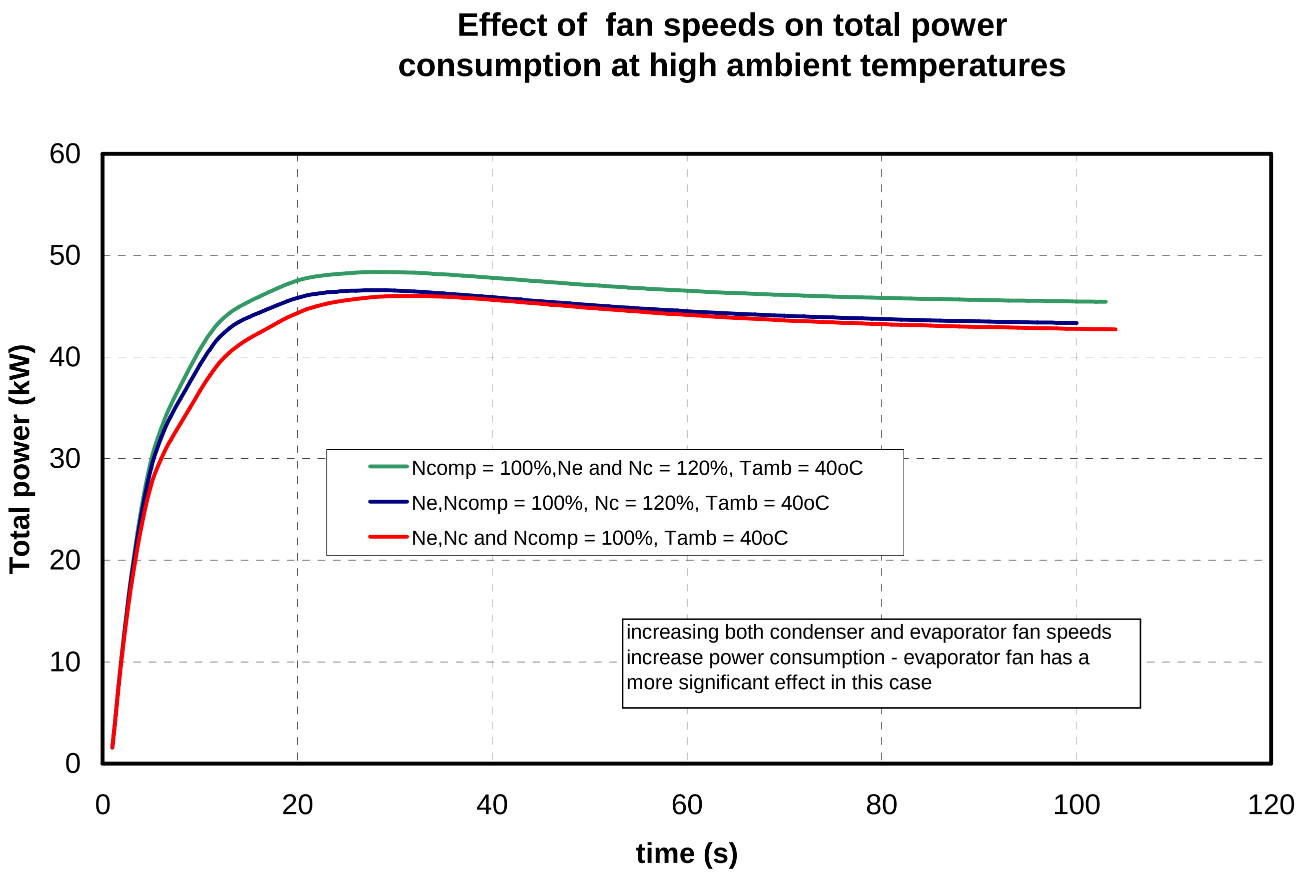
More results …

Ambient temperature and power



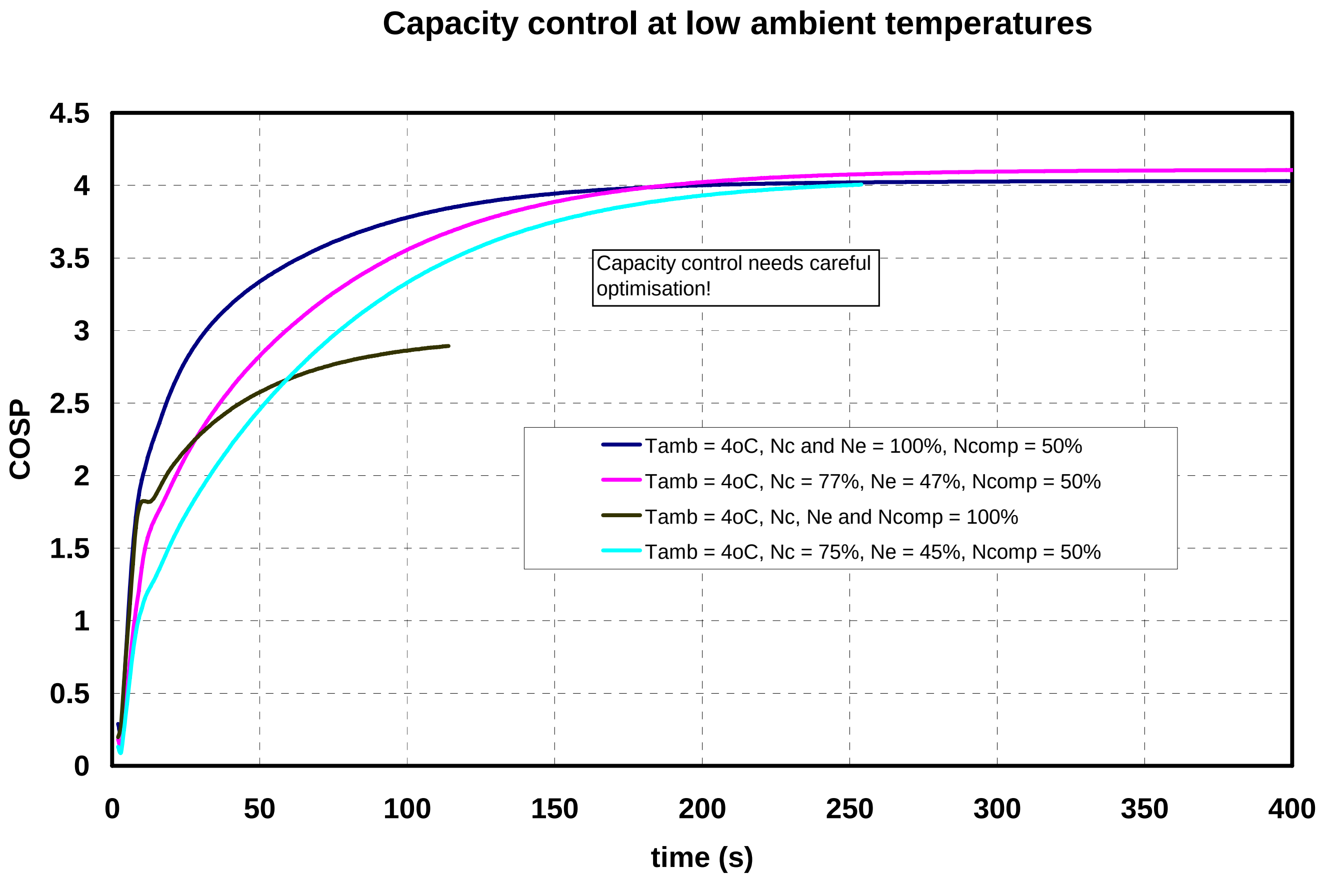
More results …

Fan speed effects at high ambient temperature



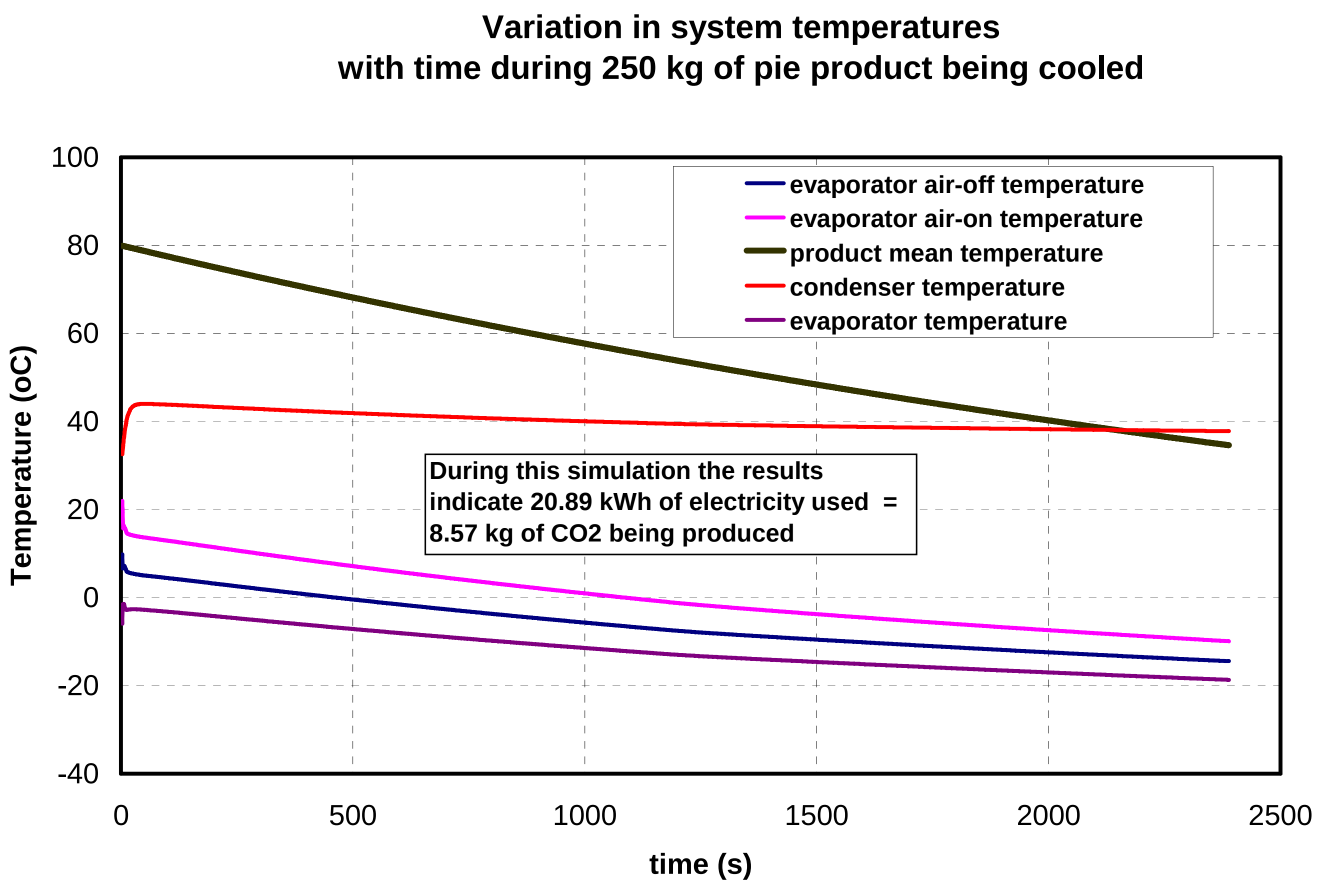
More results….

Capacity control at low ambient temperatures



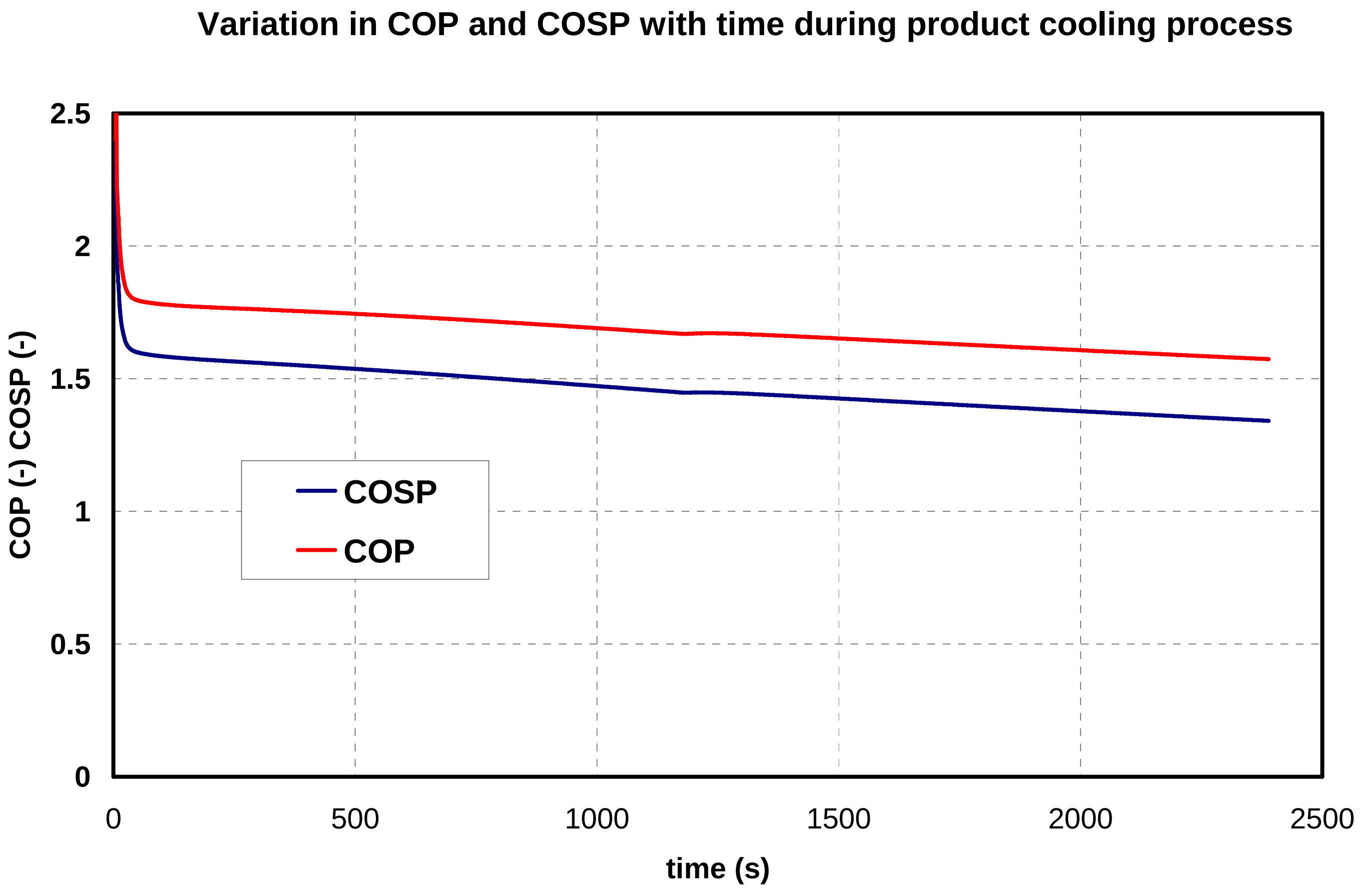
More results ….

Food product cooling



More results …

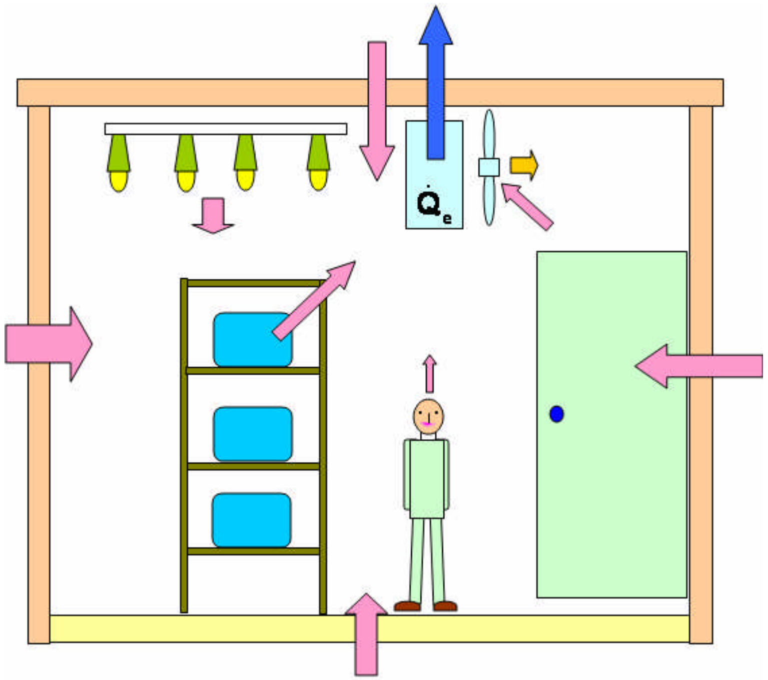
Variation in efficiency during product cooling



Cold-store simulator

- An interactive software that allows you to model the energy performance of cold or freezer room systems, including the refrigerator over a period of time.
- This software allows you to simulate product loading and unloading schedules with varying ambient conditions if needed.

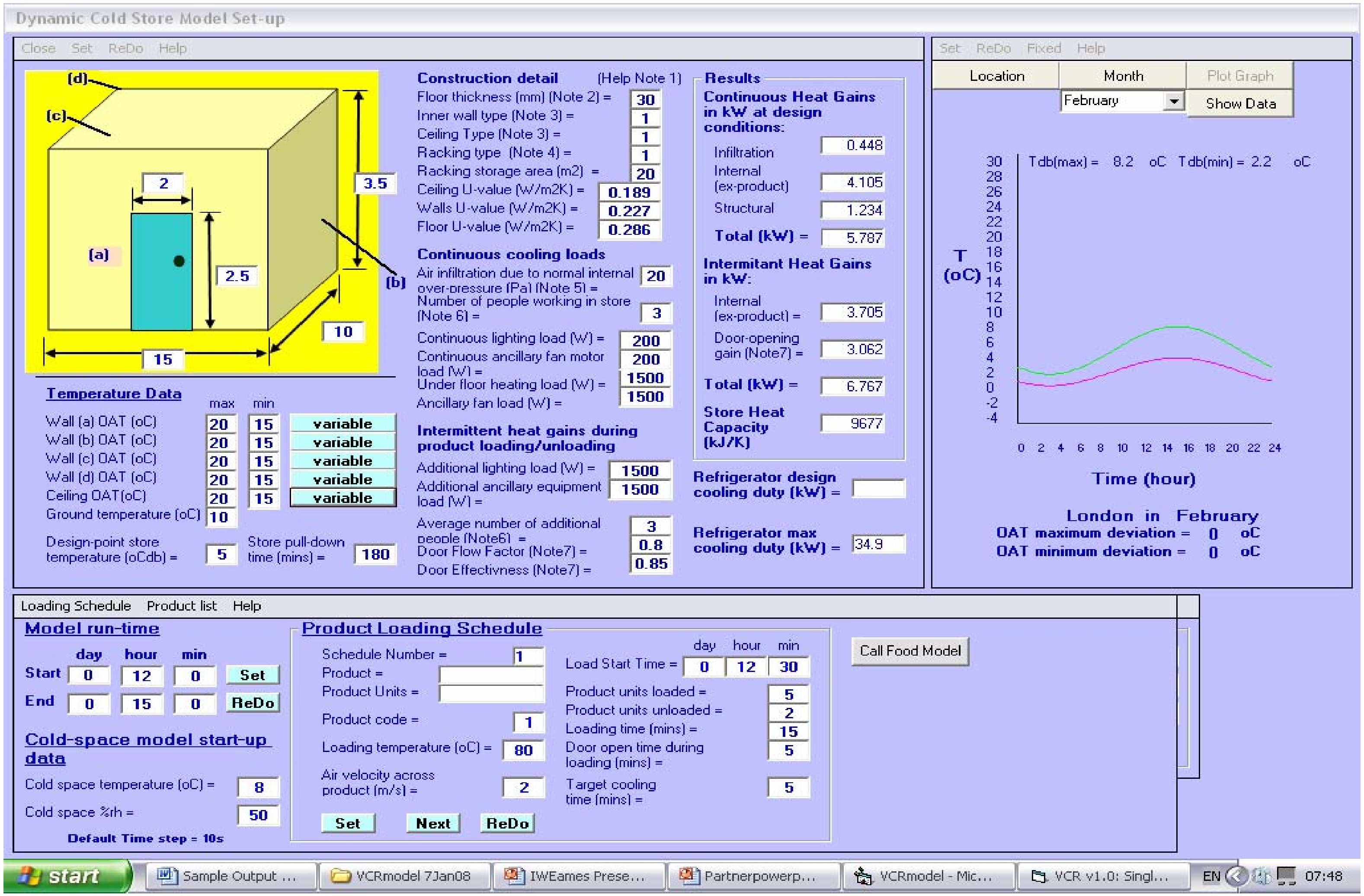
What the store model allows for:



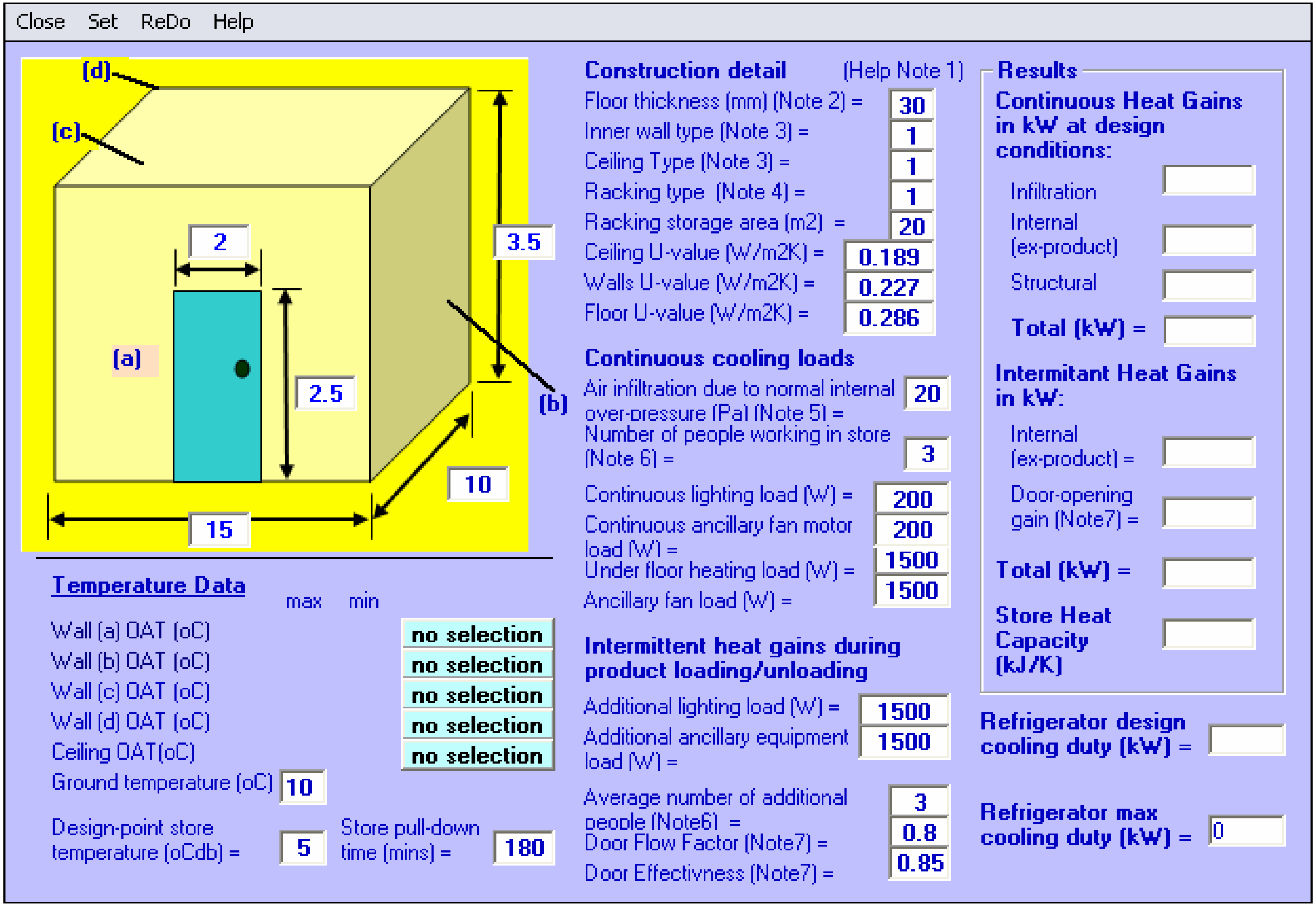
Heat gains include:

Product
Fabric
Racking
Lighting
People
Infiltration
Evaporator
Fans

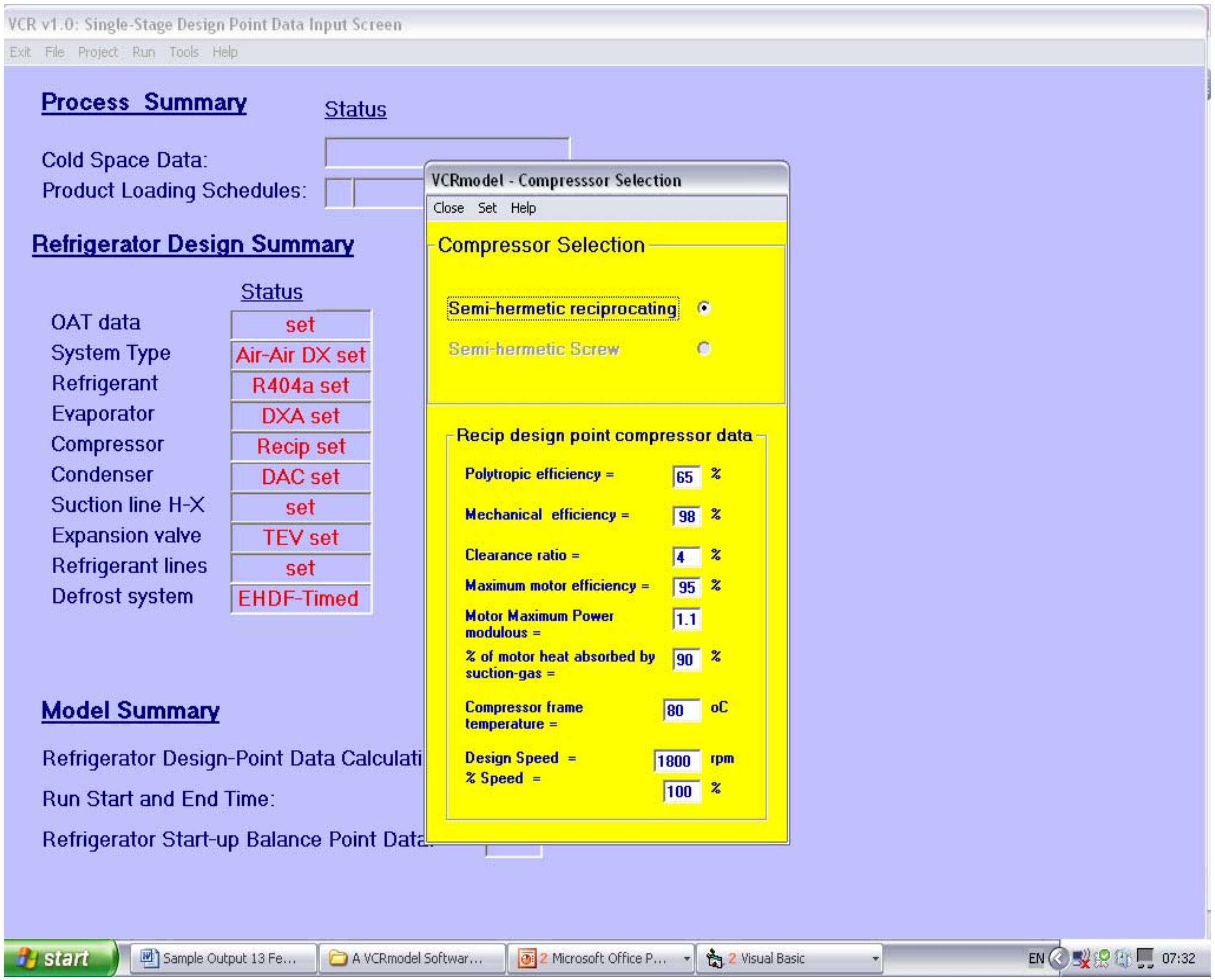
Cold store Set-up Screen



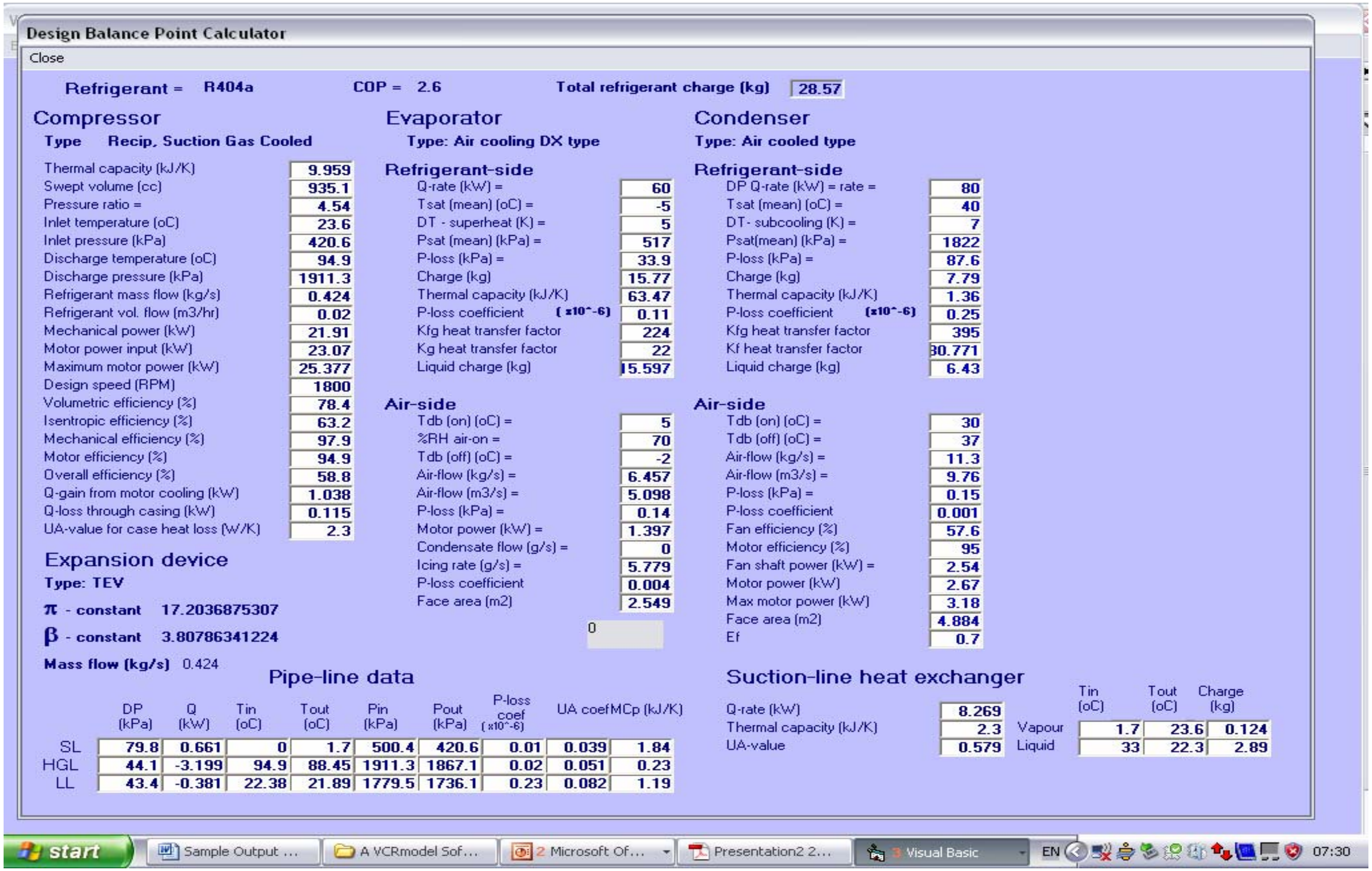
Close-up of store set-up screen…



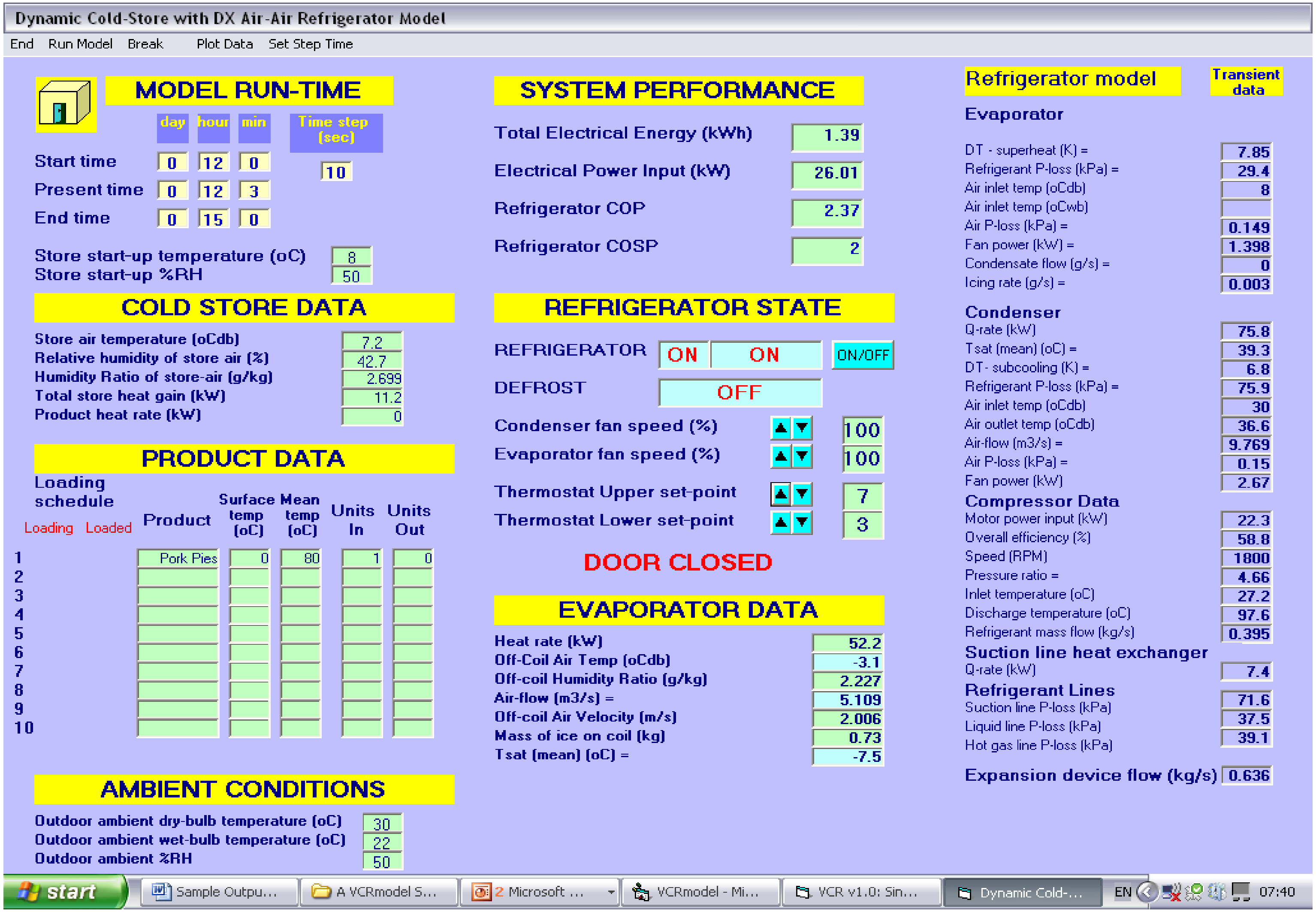
Refrigerator design screen



Refrigerator design-point output screen



The Simulator Run-Screen



What the simulator provides

During RUN-TIME …

- Information on the current Model-Time and operating mode of the refrigerator: ON/OFF, Defrosting …
- Continuously updated product temperature information, total electrical power usage and CO_2 emissions, refrigerator performance data, store data: individual heating load gains and losses, temperature, relative humidity, ambient temperature,
- Interactive control of fan speeds and thermostat settings and Time-Step, so you can speed RUN-TIME up a bit.

Future developments

Additional component and system choices:

- Fan-coils
- Evaporative condensers
- Pump-fed evaporators
- Water-cooling evaporators
- Cooling towers
- Screw Compressors
- Hot-Gas Defrost
- Intelligent controls
- Extend Properties Library
- Multi-stage compression …

Fault prediction and diagnosis

University of BRISTOL
Food Refrigeration & Process Engineering Research Centre
Brunel UNIVERSITY WEST LONDON
LONDON SOUTH BANK UNIVERSITY
University of Sunderland
defra Department for Environment Food and Rural Affairs

Concluding remarks …

We believe that through the use of simulation software, of the type you have seen during this presentation, the energy efficiency of food refrigeration systems can be optimised to minimise the CO_2 emissions produced by industry.

Concluding remarks…

There was not time to show the two simulators during this short presentation, however if anyone wishes to see a demonstration over the lunch break please feel free to ask.

Thank you for listening